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(54) Electromagnetic-wave-operated heating apparatus.

(57) In an electromagnetic-wave-operated heating apparatus in which, with a body to be heated such as a living body inserted into the cavity resonator incorporating at least one reentrant, an electromagnetic wave produced by high frequency energy supplied into the cavity resonator is used to heat the body; an electric field concentrating member is provided between the reentrant and the body in such a manner that the electric field concentrating member is provided to be electrically disconnected to the reentrant, whereby, under an ordinary condition that the body held in the apparatus is not in parallel with the end face of the reentrant, a deep portion of the body can be heated with high efficiency.

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BACKGROUND OF THE INVENTION

This invention relates to an electromagnetic-wave-operated heating apparatus in which high frequency energy is supplied to a three-dimensional resonator to produce an electric field thereby to heat a local portion of a body.

In a conventional electromagnetic-wave-operated heating apparatus, as shown in Figs. 14 and 15, in the cavity 52 of a three-dimensional resonator 51 internal electrodes 53 are formed by depressing part of the cavity 52 or by using conductors so as to provide a concentrated electric field for heating (cf. Japanese Patent Application (OPI) No. 209073/1989 (the term "OPI" as used herein means an "unexamined published application")).

In the conventional apparatus, high frequency energy is applied to the three-dimensional resonator 51 to cause resonance in the cavity 52, as a result of which a strong electric field E is formed between the internal electrodes and the conductor of the cavity 52 confronted therewith, while a strong magnetic field H is produced in such a manner as to surround the electric field E. The electric field E being enclosed by the strong magnetic field H so as not to diffuse, a strong electric field is formed which is concentrated on the central axis of the internal electrodes 53. With the electromagnetic field thus formed, a desired portion of a body 54 to be heated is heated with high concentration.

However, it has been found through experiments that, with the conventional electromagnetic-wave-operated heating apparatus, the results of heating are not always same to those which have been proposed.

In this connection, the following facts have been found: In the case where the body to be heated is in contact with the reentrants, the Q (quality factor) of the resonator is lowered, and the resonance frequency cannot be specified, so that it becomes impossible to heat the body. That is, it is necessary to provide a gap between the body and the reentrants. Only in the particular case where the ends of the reentrants are in parallel with each other, and the body to be heated is in parallel with the ends of the reentrants, a deep local portion of the body can be heated. However, in practice, this special condition is scarcely satisfied; that is, the body to be heated is somewhat not in parallel or uneven. In this case, it is impossible to heat a local portion of the body with high concentration.

SUMMARY OF THE INVENTION

Accordingly, an object of this invention is to eliminate the above-described difficulties accompanying a conventional electromagnetic-wave-operated heating apparatus.

More specifically, an object of the invention is to provide an electromagnetic-wave-operated heating apparatus with which, under the ordinary condition that the body to be heated is set not completely in parallel, a deep local portion of the body can be heated.

The foregoing object and other object of the invention have been achieved by the provision of an electromagnetic-wave-operated heating apparatus in which at least one reentrant is provided in a cavity resonator, and with a body to be heated such as a living body or an object inserted into the cavity resonator, an electromagnetic wave produced by high frequency energy supplied into the cavity resonator is used to heat the body; in which, according to the invention, an electric field concentrating member is provided between the reentrant and the body in such a manner that the electric field concentrating member is provided to be electrically disconnected to the reentrant.

In the apparatus, the heating electric field is concentrated by the electric field concentrating member, so that a deep portion of the body is heated with high efficiency.

The nature, principle and utility of the invention will become more apparent from the following detailed description when read in conjunction with the accompanying drawings, in which like parts are designated by like reference numerals or characters.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

Fig. 1 is a vertical sectional view showing an example of an electromagnetic-wave-operated heating apparatus which constitutes an embodiment of this invention:

Figs. 2 through 5 are diagrams showing examples of an electric field concentrating member employed in the apparatus shown in Fig. 1;

Fig. 6 is an explanatory diagram for a description of a correct relation between the diameter of the electric field concentrating member and the height (thickness) of a body to be heated;

Figs. 7 through 10 are diagrams showing examples of a method of fixing the electric field concentrating member;

Fig. 11 is a vertical sectional view showing another example of the electromagnetic-wave-operated heating apparatus which constitutes another embodiment of the invention;

Figs. 12 and 13 are diagrams showing modifications of the apparatus as shown in Fig. 11;

Fig. 14 is a perspective view showing a conventional electromagnetic-wave-operated heating apparatus; and

Fig. 15 is a vertical sectional view of the conventional apparatus shown in Fig. 14.

DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiments of this invention will be described with reference to the accompanying drawings.

An example of an electromagnetic-wave-operated heating apparatus, which constitutes a first embodiment of the invention, is constructed as shown in Fig. 1. That is, a cylindrical cavity resonator 1 has reentrants 4 and 4 inside of it in such a manner that they are extended toward each other from the top surface 2 and the bottom surface 3, respectively, and gaps 6 and 6 are formed between a body 5 to be heated and the reentrants 4 and 4, respectively. And electric field concentrating members 7 and 7 are placed on the body 5.

In the electromagnetic-wave-operated heating apparatus, the provision of the gaps 6 contributes to an increase of the Q (quality factor) of the cavity resonator 1. As a result, the resonance frequency of the cavity resonator can be measured, and the value of a high frequency supplied from an external oscillator (not shown) can be determined. Thus, the body can be effectively heated.

It has been found through experiments that, in the case where no electric field concentrating members 7 are used, the following difficulties are involved: That is, in this case, the electric field concentrates on parts of the edges of the reentrants 4, and the portions of the body corresponding to the edges are heated greatly. In addition, the parts of the edges on which the electric field concentrates cannot be determined, and accordingly it is difficult to heat a desired portion of the body.

On the other hand, in the case where the electric field concentrating members 7 are employed, the electric field from the reentrants 4 are concentrated on the electric field concentrating members 7 once, and then applied to the body 5. Since the electric field concentrating members 7 are placed in contact with the body 5 or near the latter 5, the electric field will not diverge. Because of the use of the cavity resonator 1, the electric field is condensed by the magnetic field formed in such a manner as to surround the electric field, so that a deep central portion of the body is heated at high temperature. It has been ensured through experiments that a desired deep portion of the body 5 held between the reentrants is heated at high temperature with high reproducibility.

The electric field concentrating members 7 are made of an electric conductor. Since current flows freely in the electric conductor, the electric field concentrates on the electric field concentrating members 7, as s result of which a deep portion of the body is heated effectively.

The electric field concentrating members 7 may be made of a dielectric. A dielectric is more electrically conductive than air. A material larger in dielectric constant is more electrically conductive. Hence, the electric field can be concentrated on the electric field concentrating member 7 made of dielectric, so that a deep portion of the body can be heated with high efficiency.

Furthermore, the electric field concentrating members 7 may be made of a material which is larger in dielectric constant than the body 5. The conductivity of current in a dielectric is proportional to the dielectric constant thereof. Hence, in the case where the dielectric constant of the dielectric forming the electric field concentrating members 7 is made larger than that of the body 5 to be heated, then similarly as in the case where the electric field concentrating member 7 are of metal, the concentration of electric field by the electric field concentrating members 7 is increased. Thus, a deep portion of the body 5 can be heated more effectively.

In order to prevent the trouble that the electric field concentrating member 7 or the body 5 to be heated falls down, a material such as a foamed styrene board small in dielectric constant may be interposed between the lower reentrant 4 and the lower electric field concentrating member 7.

In the electromagnetic-wave-operated heating apparatus thus constructed, the electric field concentrating members 7 may be brought into contact with the body 5. In this case, the current collected by the electric field concentrating members 7 is directly applied to the body 5, so that it will reach a deep portion of the body without diverging. Thus, the deep portion of the body can be heated with high efficiency.

The electric field concentrating members 7 may be each in the form of a flat plate. The flat plate shaped electric field concentrating members 7 can concentrate the electric field with high efficiency as long as they are made of an electric conductor or dielectric. Hence, in this case also, a deep portion of the body can be heated more sufficiently with high concentration.

The electric field concentrating members 7 may be in the form of a disk a shown in Fig. 2. In the use of the disk-shaped electric field concentrating members 7, the electric field concentrates on the central portion of the disk, and accordingly the concentrative heating of a deep portion of the body can be achieved more effectively.

The electric field concentrating members 7 may be so shaped that they are suitable for heating the body. In this case, the electric field is concentrated in the form similar to the configuration of the electric field concentrating members 7.

Therefore, the body 5 will be heated in the form in which it is to be heated.

Furthermore, each of the electric field concentrating members 7 may be each in the form of a three-dimensional member which has a certain thickness, and is hollow. Even if the electric field concentrating members 7 are each hollow, current will flow along the outer surfaces of the electric field concentrating members 7 to the center of its surface confronting with the body 5 to be heated. Thus, the effects of the hollow electric field concentrating members 7 are the same as those of the solid electric field concentrating members 7. Employment of the hollow electric field concentrating members 7 contributes to the economical use of material.

In addition, each of the electric field concentrating members 7 may be each in the form of a three-dimensional member which has a certain thickness, and is solid. In this case, the electric field concentrating members 7 may be formed of a material uniform in quality. As the thickness of the electric field concentrating members 7 is increased, the distance between the electric field concentrating member 7 and the reentrant 4 is decreased as much, and accordingly the concentration of the electric field is accelerated as much. Since the electric field concentrating members 7 are solid, current can flow through the inside of the electric field concentrating member to the center of the surface confronting with the body 5 to be heated. Thus, the concentrative heating of a deep portion of the body 5 can be achieved more effectively.

In the case of providing each of the electric field concentrating members 7 as a three-dimensional one, it may be formed cylindrical as shown in Figs. 3, 4 or 5. In this case, the body 5 is heated in such a manner that the heated portion is circular in horizontal section. Being circular, the electric field concentrating members 7 have no protrusions, and accordingly the electric field is concentrated on the center thereof. Hence, the concentrative heating of a deep portion of the body 5 can be achieved more effectively.

In the case of providing each of the electric field concentrating members 7 as a three-dimensional one, its end portion may be formed similar to the configuration in horizontal section of a portion of the body which is to be heated. With the electric field concentrating members 7 thus formed, the electric field concentrates in the form which is similar the configuration of the end portion thereof, and accordingly, the body is heated in the form in which it should be heated.

In the case where the electric field concentrating member 7 is circular as shown in Figs. 2 and 3, it is preferable that the diameter (d) of the member 7 is at least 1.5 times the thickness (ℓ) of the body 5 to be heated.

It has been found through experiments that, when the diameter of the electric field concentrating members 7 is small, then the concentrative heating of a deep portion of the body 5 cannot be achieved. That is, the electric field collected by the electric field concentrating members 7 diffuses before reaching the deep portion of the body. In the case where the diameter of the electric field concentrating members 7 is large, the electric field will not diffuse, and instead it is condensed by the magnetic field surrounding it, so that the deep portion of the body can be heated with high concentration. Thus, it has been found through experiments that there is a relation between the diameter of the electric field concentrating members 7 and the thickness of the body 5 to be heated; that is, if the diameter of the electric field concentrating members 7 is at least 1.5 times the thickness of the body 5, then the concentrative heating of a deep portion of the body can be accomplished.

As shown in Fig. 4, the electric field concentrating member 7 may be made up of two three-dimensional structures 8 and 9. In this case, the structure 9 is inserted into the structure 8 so that the electric field concentrating member is adjustable in height. Since the height of the electric field concentrating member 7 is adjustable, the resonance frequency of the cavity resonator 1 can be changed. In general, the resonance frequency of the cavity resonator 1 changes with the height of the body 5 to be heated, and therefore it is necessary to change the frequency of the power generator (not shown). However, to change the frequency of the power generator to a desired value is not economical, because to do so is considerably expensive. This difficulty can be overcome by the method in which the change in height of the body 5 is absorbed by changing the thickness (height) of the electric field concentrating members 7. That is, according to the method, the resonance frequency of the cavity resonator 1 can be maintained constant at all times. The oscillator is economical, being manufactured at low cost.

In order that the three-dimensional structures 8 and 9 forming the electric field concentrating member 7 are electrically in contact with each other, it is effective to dispose electrically conductive materials or electrical conductive elastic materials 10 between the three-dimensional structures 8 and 9 as shown in Fig. 5. In the case where the structures 8 and 9 are made of an rigid material, then they are not always in good contact with each other. This difficulty may be overcome by interposing the electrical conductive material or electrical conductive springs 10 between the three-dimensional structures 8 and 9. In this case, current flows

between the two structures 8 and 9 sufficiently. Hence, the concentrative heating of a deep portion of the body 5 can be achieved with high efficiency.

In order that the structures 8 and 9 are held electrically in contact with each other, they may be made of an electrically conductive elastic material. Furthermore, for the same purpose, the contact portions of the structures 8 and 9 may be made of an electrically conductive elastic material. The structures 8 and 9 thus formed are sufficiently electrically brought into contact with each other, so that current will flow between them sufficiently, thus reaching the center of the surface thereof which confronts with the body. Thus, a deep portion of the body can be heated with high concentration.

In order to make the structures 8 and 9 electrically conductive, it is effective to interpose dielectric materials or dielectric elastic materials between the contact regions of those structures 8 and 9 as shown in Fig. 5. If the structures 8 and 9 are made of a rigid material, then they are not always held in good contact with each other. This difficulty may be overcome by interposing the dielectric materials or dielectric elastic materials between the three-dimensional structures 8 and 9. In this case, current flows between the structures 8 and 9 satisfactorily, as a result of which the concentrative heating of a deep portion of the body can be achieved more effectively.

In order that the structures 8 and 9 are held electrically in contact with each other, they may be made of a dielectric elastic material. Furthermore, for the same purpose, the contact portions of the structures 8 and 9 may be made of a dielectric elastic material. The structures 8 and 9 thus formed are sufficiently electrically brought into contact with each other, so that current will flow between them sufficiently, thus reaching the center of the surface thereof which confronts with the body. Thus, the effect that a deep portion of the body is heated with high concentration is obtained sufficiently.

The electric field concentrating members 7 are supported as shown in Fig. 7. That is, the members 7 are secured through insulators 11 to the reentrants 4, respectively. Merely with the electric field concentrating members 7 placed on the body 5 to be heated, the concentration of electric field is effected. However, when the electric field concentrating members 7 are pushed against the body 5 to be heated, the concentration of electric field is accelerated. Hence, the apparatus should be so designed that the electric field concentrating members 7 are secured through the insulators 11 to the reentrants 4 whereby pressure is applied to the electric field concentrating members 7.

The length of the insulators 11 for securing the electric field concentrating members 7 may be made variable by means of screws 12 as shown in Fig. 8 so that the condition of contact of the electric field concentrating members 7 with the body 5 to be heated be adjustable. For the above-described reason, the electric field concentrating members are secured in the above-described manner; however, if the pressure is excessively high, then it may adversely affect the body 5 to be heated. Therefore, the length of the insulators 11 is adjusted so that the most suitable pressure is applied to the body 5 to be heated.

As shown in Fig. 9, an electric motor may be provided inside the reentrant. The motor thus provided is used to drive gears 13, 14 and 15 successively, or to drive the gear 14 directly to drive a rack formed on the insulators 11, thereby to move the insulators 11 back and forth so that the condition of contact of the electric field concentrating members 7 with the body 5 to be heated be adjusted. That is, by controlling the motor, the most suitable pressure can be obtained for the body 5 to be heated.

The electric field concentrating members 7 may be secured to the wall 17 (or the top 2 or the bottom 3) of the cavity resonator 1 through insulators 16 as shown in Fig. 10. For the same reason as described above, with the electric field concentrating members 7 secured in the above-described manner, the electric field can be concentrated more effectively.

In Fig. 10, the insulators 16 for securing the electric field concentrating members 7 are movable on the wall 17 of the cavity resonator 1. The insulators 16 are fixedly secured to the wall 17 with fixing members 18 so that the condition of contact of the electric field concentrating members 7 with the body 5 to be heated is best. In this case, the pressure applied to the body 5 to be heated can be changed to a desired value.

It is preferable that the two electric field concentrating members 7 are so secured that their surfaces confronted with each other are in parallel with each other as shown in Fig. 7.

In the case where the two surfaces of the electric field concentrating members 7 confronted with each other are large and not in parallel with each other, then the electric field concentrates on the parts of the electric field concentrating members 7 which are the closest in space, and accordingly the parts are locally heated (such a condition is necessary as the case may be, and therefore in such as case, the electric field concentrating members are intentionally made not in parallel). In general, this phenomenon is against the object of heating the body. Hence, the electric field concentrating members 7 are so secured that the two confronted surfaces are as parallel with each other as possible.

In the case where only one electric field concentrating member is employed, it should be secured in such a manner that its surface is in parallel with the surface of the reentrant which confronts through the body to be heated with the electric field concentrating member.

Fig. 11 outlines another example of the electromagnetic-wave-operated heating apparatus which constitutes a second embodiment of the invention. In the apparatus, bags 19 and 19 are disposed between the body 5 to be heated and one of the electric field concentrating members 7 and between the body and the other electric field concentrating member 7, respectively. The bags 19 contain a solution 20.

The electric field concentrating members 7 are fixedly secured in such a manner that they are in parallel with each other. Even when the electric field concentrating members 7 are held in contact with the body 5 to be heated, the condition of contact is poor if the surfaces of the body 5 are not flat. That is, in this case, the area of contact is not large enough, and accordingly current will not sufficiently flow into the body 5 through the electric field concentrating members 7. In order to overcome this difficulty, the bags 9 are interposed between the body 5 and one of the electric field concentrating members 7 and between the body 5 and the other electric field concentrating member 7, respectively, and then the solution 20 is injected into the bags 9 thus interposed. With the bags interposed in this manner, the bags 19 are held sufficiently in contact with the body 5 to be heated; that is, the total area of contact is large enough. As a result, a deep portion of the body can be heated with high concentration, and the bags will provide an effect of cooling the surface of the body 5.

The above-described apparatus may be modified as shown in Fig. 12. Each of the bags 19 is connected through a pipe 21 to a solution reservoir 22. The height of the bag is changed, or the pressure applied to the surface of the solution in the reservoir is changed, to adjust the quantity of solution in the bag 19 thereby to adjust the condition of contact of the bag with the body 5 to be heated and to adjust the resonance frequency of the cavity resonator 1. By adjusting the quantity of solution in the bag 19, the thickness of the bag is adjusted, whereby the condition of contact of the bag 19 with the body 5 is adjusted, while the resonance frequency of the cavity resonator 1 is changed. That is, the resonance frequency of the cavity resonator 1 is decreased by increasing the thickness of the bag 19, and it is increased by decreasing the thickness of the bag 19. Hence, the resonance frequency of the cavity resonator 1 can be adjusted to a desired value by adjusting the quantity of solution in the bag.

Fig. 13 shows another modification of the electromagnetic-wave-operated heating apparatus, which is so designed as to cool the surface of the body 5. The solution 20 in the bags 19 is circulated through pipes 21 and an external cooling unit 23, thereby to cool the surface of the body 5. With the apparatus, the surface of the body can be cooled by cooling the solution 20 which is supplied into the bags. For this purpose, the solution 20 is circulated through the external cooling unit 23 so that it is maintained at low temperature at all times, and accordingly the surface of the body is cooled by thermal conduction.

The solution 20 in the bags 19 may be of dielectric. The bags 19 are interposed between the body 5 and one of the electric field concentrating members 7 and between the body 5 and the other electric field concentrating member 7, respectively, as was described above, and the solution 20 equal in dielectric constant to the body 5 is supplied into the bags 19 thus interposed. In this case, even if the body 5 is not held in parallel with the reentrants, equivalently the body 5 is in parallel therewith. Thus, a deep portion of the body can be heated effectively.

It is preferable that the dielectric supplied into the bags 19 is larger in dielectric constant than the body 5 to be heated. Current will flow in a substance in proportion to its dielectric constant. Hence, in the case where the solution 20 which is higher in dielectric constant than the body 5 is supplied into the bags 19, the resistance of the bags 19 against the flow of current is decreased as much, so that the current will flow in the body more effectively. Thus, a deep portion of the body can be heated with high efficiency.

In the above-described apparatus, the electric field concentrating members 7 which are coupled to, or brought into contact, or set near the above-described bags 19 may be any of those shown in Figs. 2 through 6, or they may be eliminated, or instead of the electric field concentrating members 7 flat plates (whose material is not specified) may be employed. The electric field concentrating members 7 may be secured according to any of the methods described with reference to Figs. 7 through 9, or according to the methods in combination. It is obvious that any of the electric field concentrating members 7 shown in Figs. 2 through 6 function satisfactorily. When the electric field concentrating members 7 are merely coupled to the bags 19, sometimes the two electric field concentrating members 7 may not be held in parallel with each other, or the body 5 to be heated may be moved. In order to eliminate these difficulties, the electric field concentrating members 7 are secured according to any of the methods described with reference to Figs. 7 through 9, or according to

the methods in combination.

The technical concepts of the above-described embodiments can be applied to an electromagnetic-wave-operated heating apparatus in which the reentrants 4 are not in contact with the top 2 and the bottom 3 of the cavity resonator 1.

As was described above, in the electromagnetic-wave-operated heating apparatus of the invention, the electric field concentrating members 7 are provided between the body to be heated and one of the reentrants and between the body and the other reentrants so the reentrants are not in contact with the body. Therefore, the heating electric field applied from the reentrants to the body to be heated is concentrated by the electric field concentrating members 7, thus heating a deep portion of the body with high efficiency.

While there has been described in connection with the preferred embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is aimed, therefore, to cover in the appended claims all such changes and modifications as fall within the true spirit and scope of the invention.

Claims

1. An electromagnetic-wave-operated heating apparatus in which at least one reentrant is provided in a cavity resonator, and with a body to be heated such as a living body or an object inserted into said cavity resonator, an electromagnetic wave produced by high frequency energy supplied into said cavity resonator is used to heat said body,

   characterized by comprising:

   an electric field concentrating member provided between said reentrant and said body in such a manner that said electric field concentrating member is provided to be electrically disconnected to said reentrant.

2. An apparatus as claimed in claim 1, in which said electric field concentrating member is made of an electric conductor.

3. An apparatus as claimed in claim 1, in which said electric field concentrating member is made of a dielectric.

4. An apparatus as claimed in claim 3, in which said dielectric forming said electric field concentrating member is larger in dielectric constant than said body to be heated.

5. An apparatus as claimed in claim 1, in which said electric field concentrating member is brought into contact with said body to be heated.

6. An apparatus as claimed in claim 1, in which said electric field concentrating member is in the form of a flat plate.

7. An apparatus as claimed in claim 1, in which said electric field concentrating member is circular.

8. An apparatus as claimed in claim 1, in which said electric field concentrating member is shaped in compliance with the configuration of a portion of said body which is to be heated.

9. An apparatus as claimed in claim 1, in which said electric field concentrating member is a three-dimensional one with a cavity therein.

10. An apparatus as claimed in claim 9, in which said cavity in said electric field concentrating member is filled with a material.

11. An apparatus as claimed in any of claims 9 and 10, in which said electric field concentrating member is cylindrical.

12. An apparatus as claimed in any of claims 9 and 10, in which the surface of said electric field concentrating member which confronts with said body to be heated is shaped in compliance with the configuration of a portion of said body which is to be heated.

13. An apparatus as claimed in claim 7, in which the diameter of said electric field concentrating member is at least 1.5 times the thickness of the body to be heated.

14. An apparatus as claimed in claim 1, in which said electric field concentrating member comprises two bottomed cylinders which are fitted together in such a manner that one of said two bottomed cylinders is inserted into the other.

15. An apparatus as claimed in claim 14, in which contact members which are made of an electrically conductive material or electrically conductive elastic material are interposed between the engaging surfaces of said two bottomed cylinders forming said electric field concentrating member in such a manner that said two bottomed cylinders are electrically connected to each other.

16. An apparatus as claimed in claim 14, in which contact member which are made of an dielec-

tric material or dielectric elastic material are interposed between the engaging surfaces of said two bottomed cylinders forming said electric field concentrating member.

17. An apparatus as claimed in claim 1, in which said electric field concentrating member is supported through insulators on said reentrant.

18. An apparatus as claimed in claim 17, in which said electric field concentrating member includes a support which is movable, said support being moved to adjust the condition of contact of said electric field concentrating member with said body to be heated.

19. An apparatus as claimed in claim 17, in which the length of an insulator adapted to fixedly secure said support of said electric field concentrating member is adjusted by means of an electric motor, to adjust the condition of contact of said electric field concentrating member with said body to be heated.

20. An apparatus as claimed in claim 1, in which said electric field concentrating member is supported through an insulator on a wall of said cavity resonator.

21. An apparatus as claimed in claim 1, in which an insulator adapted to secure said electric field concentrating member is movable on a wall of said cavity resonator, said insulator being moved to adjust the condition of contact of said electric field concentrating member with said body to be heated.

22. An apparatus as claimed in claim 1, in which two electric field concentrating members are provided in said cavity resonator in such a manner that the surfaces thereof which are confronted with each other are in parallel with each other.

23. An apparatus as claimed in claim 1, in which one electric field concentrating member is provided in said cavity resonator in such a manner that the surface thereof which confronts with said body to be heated is in parallel with the end face of said reentrant.

24. An apparatus as claimed in claim 1, in which a bag is interposed between said electric field concentrating member and said body to be heated, said bag containing a solution.

25. An apparatus as claimed in claim 24, which comprises means for adjusting the quantity of solution in said bag.

26. An apparatus as claimed in claim 24, which comprises means for circulating the solution contained in said bag.

27. An apparatus as claimed in claim 24, in which said solution is of a dielectric.

28. An apparatus as claimed in claim 27, in which said solution of dielectric is larger in dielectric constant than said body to be heated.

29. An apparatus as claimed in claim 1, in which said electric field concentrating member is a three-dimensional one with a cavity therein, said electric field concentrating member is cylindrical, and the surface of said electric field concentrating member which confronts with said body to be heated is shaped in compliance with the configuration of a portion of said body which is to be heated.

30. An apparatus as claimed in claim 29, in which said cavity in said electric field concentrating member is filled with a material.

31. An apparatus as claimed in claim 1, in which said electric field concentrating member is a three-dimensional one with a cavity therein, said electric field concentrating member is cylindrical, and the diameter of said electric field concentrating member is at least 1.5 times the thickness of the body to be heated.

32. An apparatus as claimed in claim 31, in which said cavity in said electric field concentrating member is filled with a material.

Fig. 1

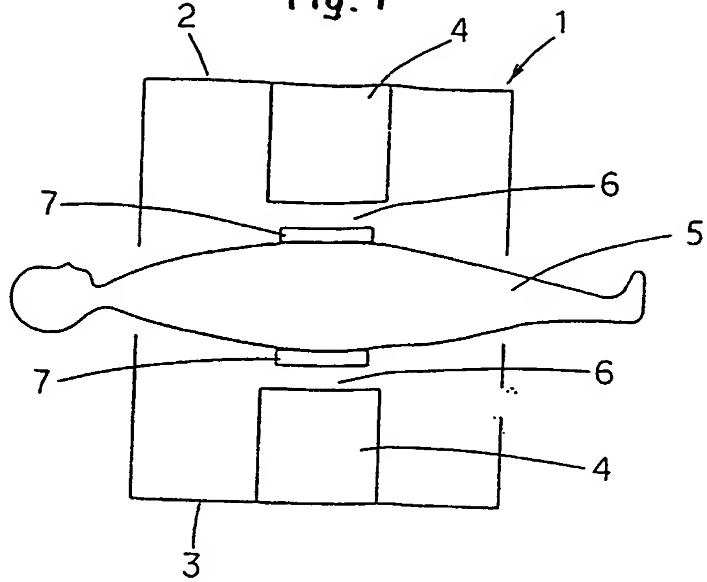

Fig. 2

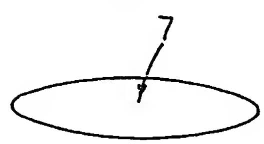

Fig. 3

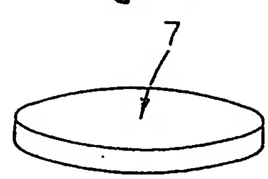

Fig. 4

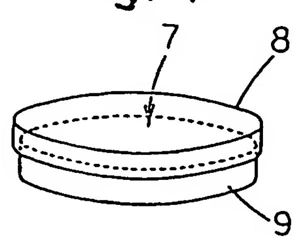

Fig. 5

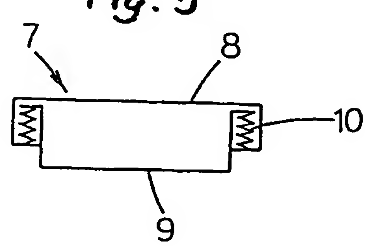

Fig. 6

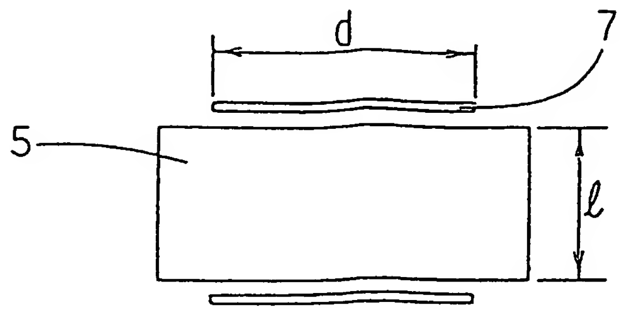

Fig. 7

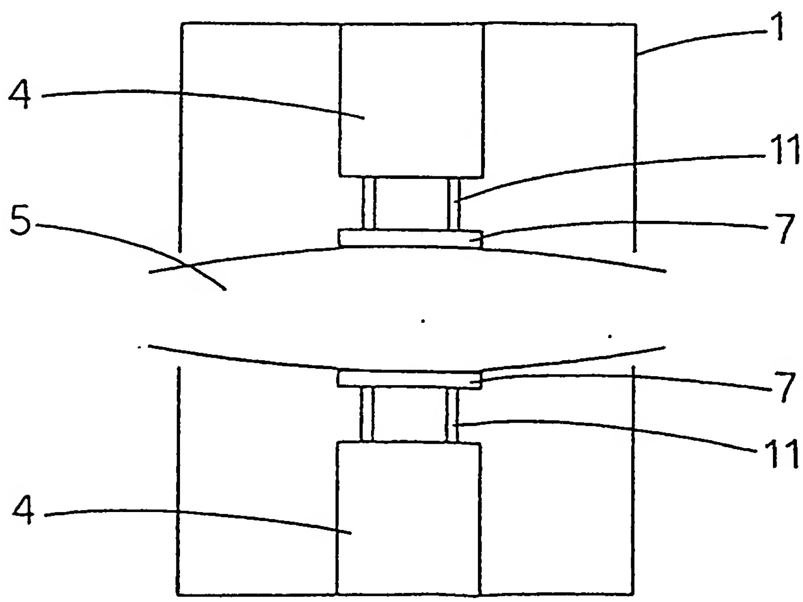

Fig. 8

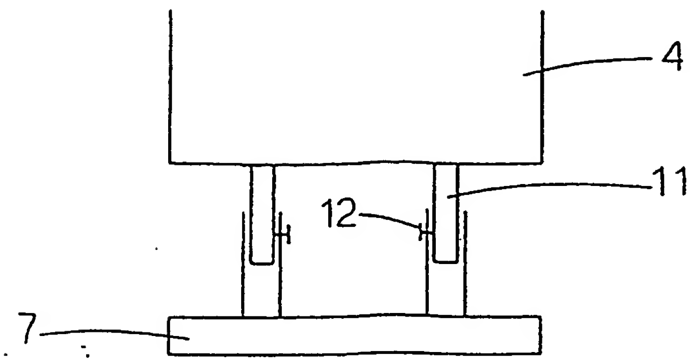

Fig. 9

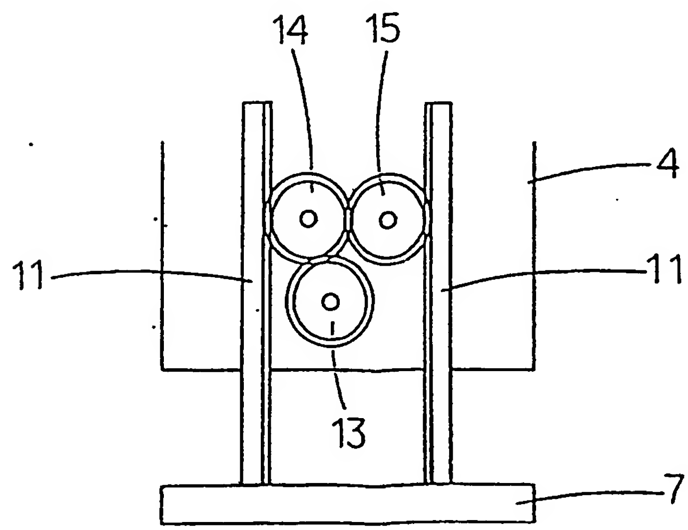

Fig. 10

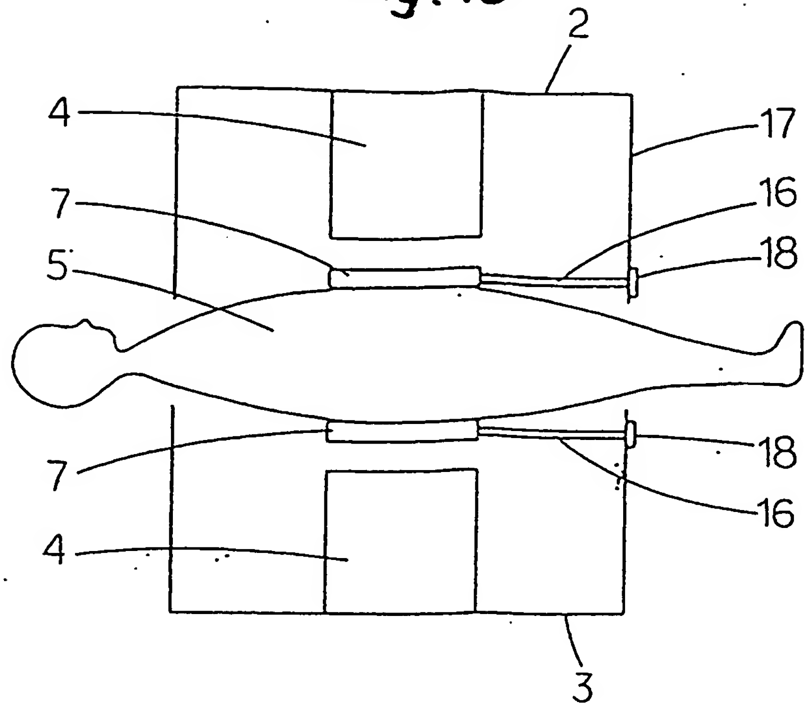

Fig. 11

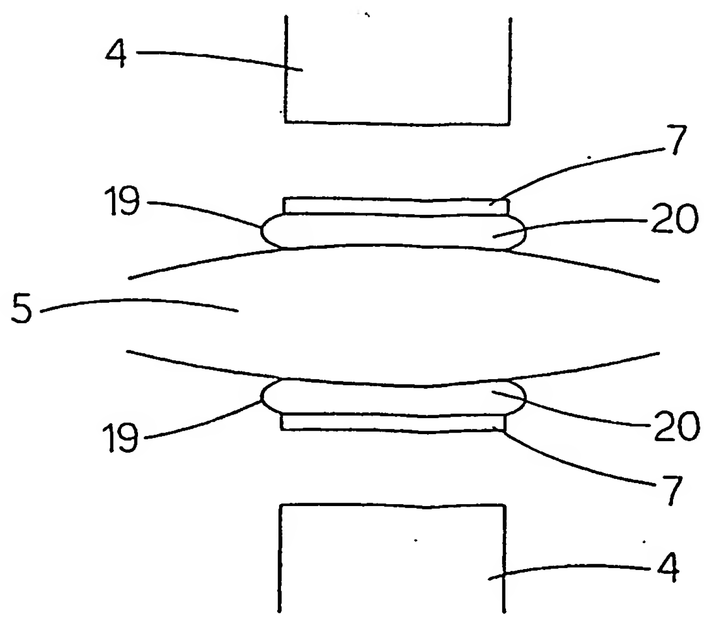

Fig. 12

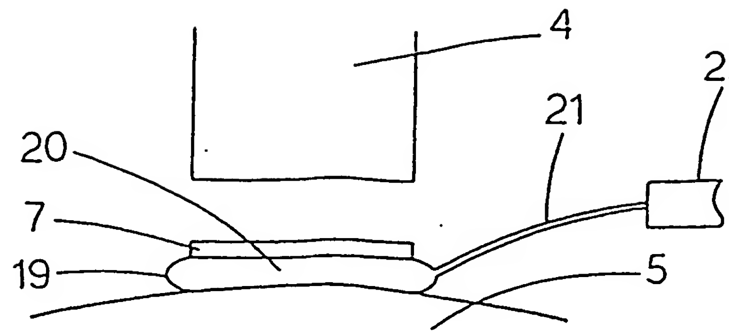

Fig. 13

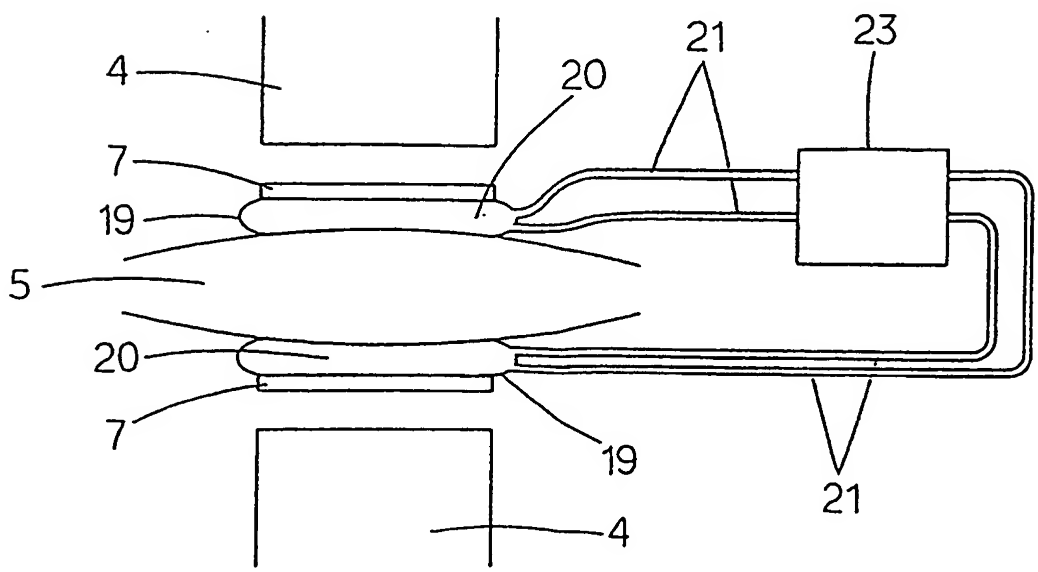

Fig. 14

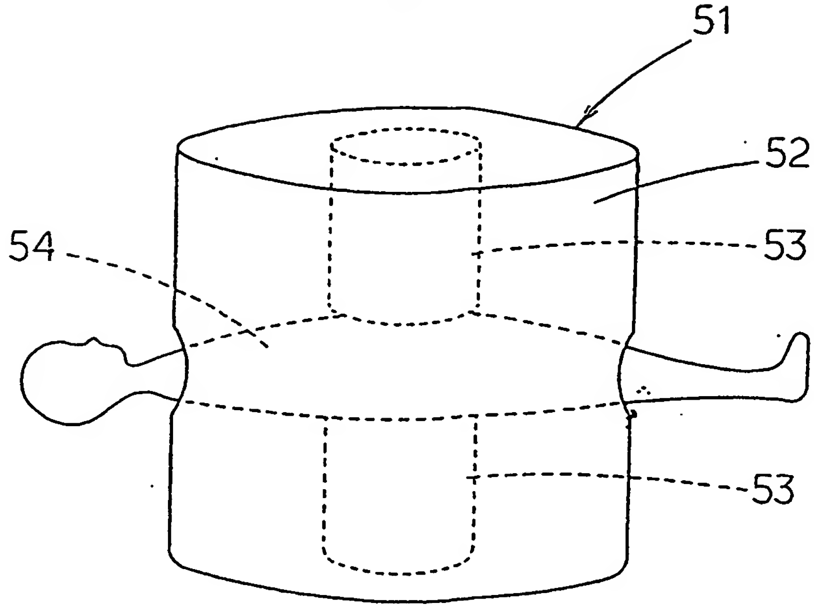

Fig. 15